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Highly Compressed Filter Tow Bales

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(71) Applicant (*for all designated States except US*):
RHODIA ACETOW GMBH [DE/DE]; Engesserstrasse 8, 79108 Freiburg (DE)

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **MESSNER, Ludwig** [DE/DE]; Wannerstr. 16, 79106 Freiburg (DE). **TEUFEL, Eberhard** [DE/DE] Schwarzwaldstrasse 46, 79194 Gundelfingen (DE). **KRAMIS, Alois** [DE/DE]; Runzstrasse 14, 79102 Freiburg (DE). **GERLITZKI, Manfred** [DE/DE]; Johannisberg Strasse 16, 79102 Freiburg (DE). **MEIER, Friedrich** [DE/DE]; Mundingerstrasse 23, 79312 Emmendingen (DE). **SEXAUER, Wolfgang** [DE/DE]; Alte Strasse 9, 79249 Merzhausen (DE).

(74) Agent: **HAGEMANN, Heinrich, etc.**; Hagemann, Braun & Held, PO Box 860 329, 81630 Munich (DE).

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(54) Title: HIGHLY COMPRESSED FILTER TOW BALES

(57) **Abstract:** The invention relates to a highly compressed filter tow bale with a packing density of more than 450 kg/m^3, having on the surface thereof an average Shore hardness of less than 50, with no localised values of hardness greater than 60 and a tow width in the bale of less than 50mm, when the tow has a total titre of more than 30,000 dtex, or the tow width in the bale is a maximum of 1.7 * 10^{-6} (m/dtex) * total titre when the tow has a total titre of less than 30,000 dtex, with an aggregation value of over 20 and effective layer width of less than 65mm.

Highly-Compressed Filter Tow Bales

The invention relates to highly compressed bales made of filter tow for cigarette filters.

The vast majority of cigarette filters used nowadays is made of filter tow, which consists of continuous cellulose-2,5-acetate filaments. Following spinning, the individual filaments are combined into a band and then crimped in a crush chamber. Thereafter, the product is dried, placed in storage containers and finally compressed into bales. Depending on the bale format, these bales weigh between 350 and 650 kg, while in exceptional cases highly compressed bales, so-called "high density tow bales", with weights of up to 900 kg can be obtained. These latter kinds of bales are described in US Patent Application US 4,577,752 for example.

Following transport of the filter tow bales to the filter or cigarette manufacturer, the filter tow is removed from the bales, and processed into filter rods on a filter rod machine of the type described for example in US Patent Application US 5,460,590. For this purpose, the filter tow is drawn out of the bale, and then expanded pneumatically to a width of 100 mm or more, stretched in a stretching unit, provided with an additive that serves to bond together the filaments and then, following the formation of a three-dimensional slub, introduced into a formatting unit with the help of a pneumatic feed funnel, where it is compressed transverse to the axial direction, wrapped with paper and cut to the final length of the filter plug.

The essential quality characteristic to the consumer consists of the homogeneity of the produced filter rods with respect to the draw resistance, since this influences the taste sensation of the smoker and filter performance. In this context, the still acceptable draw resistance scatter is dependent on the absolute value of the draw resistance. In general, a coefficient of variation of maximally 3.5% is still barely acceptable when averaging at least 10 random samples consisting of 5 measured filter rods each. As a rule, however, a mean value of less than 3.2% is the goal. None of the individual values of the coefficients of variation of these at least 10 random samples should be higher than 4.5%.

The homogeneity of the filter rods in regards to the draw resistance is influenced by a number of factors, for example, by the quality of the filter tow, by the packing, as well as by the processing method. In regards to the packing, this factor is important for an undisturbed withdrawal of the filter tow from the bale. Fluctuations in the draw resistance are seen with increasing frequency due to the ever-increasing packing density of the bales. While average values of 350 kg/m^3 were common 10 years ago, the current packing density of filter tow bales is between 450 and 500 kg/m^3. Unwinding-dependent process problems frequently occur in the case of these highly compressed bales. Changes in the tension when drawing off the filter tow result in uneven elongations of the material during the feed into the filter rod machine and therefore in material and draw resistance fluctuations.

The object of the present invention is to present a highly compressed filter tow bale, in which case the previously mentioned processing problems are largely eliminated.

In accordance with the invention, this objective is realized by means of a filter tow bale according to Claim 1.

The filter tow bale according to the invention, with a packing density of more than 450 kg/m^3, on its surface, measured vertically with respect to the lay of the tow, exhibits an average Shore hardness of less than 50, without any local Shore hardness values of more than 60 being present, and with the tow width in the bales being less than 50 mm, when the tow has a total titer of more than 30,000 dtex, or the tow width in the bale being maximally 1.7×10^{-6} (m/dtex) x total titer (dtex), when the tow has a total titer of less than 30,000 dtex, in which case the value of the aggregation value is greater than 20 and the effective layer width is less than 65 mm.

It has been shown that the hardness value is an excellent indicator for an undisturbed drawing of the filter material from the bale. Consequently, the scattering of draw resistance values of the produced filter rods can be influenced in a positive manner as a result of a suitable packing strategy. Aside from a uniform crimping of the filter tow, which, however, is already determined by the production process, the subsequent processing steps can be considerably simplified and malfunctions minimized as a result of an optimization of the tow coiling. Even in the case of

highly compressed bales, whose packing density is greater than 450 kg/m^3 [TN1], care has to be taken that the average hardness remains below the stated value. The average hardness of a bale is defined as that average value that results from 10 times 9 different measurements at the locations of the surface of the filter tow bale marked in the measurement scheme 1: this is used for the determination of the hardness of the bale with the help of the method Shore A stated in DIN 53 505, Version 2000-08 (Testing of Rubber and Elastomers according to Shore A and D).

In general, the adhesion from band to band or also the adhesion from fiber to fiber increases as a function of an increasing bale density, which results in negative consequences - in terms of the draw resistance - on the product homogeneity achieved during processing. Consequently, care has to be taken that the average hardness of the bales, despite the increasing band adhesion, remains within the framework stated in accordance with the invention. The risk of increased scattering of the draw resistance in the final product, i.e. in the finished filter rod, increases significantly as a function of increasing hardness as was shown during various measurements carried out within the context of the present invention. These measurements have shown that considerable scattering of the draw resistance in individual random samples occurs during processing as soon as the average hardness exceeds the critical value of 50. Coefficients of variation in regards to the average draw resistance of clearly more than 4.5% were found in individual random samples even when the average value of coefficients of variation from 10 random samples was less than 3.5%, i.e. still within the range considered as acceptable.

In order to avoid the occurrence of locally increased hardness values, care should be taken during the packing of the filter tow bales that severe constrictions are avoided when tapes are used. The correct packing of filter tow bales, however, is not a subject matter of this invention. Possible solutions to the packing problem are described, for example in US Patent Application US 577,752, as well as in particular in G 7635849.1 [sic], in which case a packing without tapes in described in the latter document.

[TN1] **Translator's Note:** the German source text reads "450 g/m^3," which appears to be an error, because all previous packing densities were provided in <u>kg</u>/m^3.

In order to obtain the low hardness values according to the invention, it is important that the ratio of the non-compressed volume of a filter tow bale and the compressed volume be kept as low as possible. In this context, the non-compressed volume is defined at that volume which results from the gravity-dependent pre-compression or from a mechanical pre-compression of the filter tow in the [so-called] filling can. The non-compressed volume of the filter tow bale can be calculated in accordance with the following formula:

$$V_U - L \times B_B \times A \times H_L$$

in which case L denotes the length of the bale, B_B denotes the width of the bale, A denotes the number of layers and H_L denotes the height of a layer.

Tests were able to show that bales with a filling density of greater than 450 kg/m^3 can no longer be processed without malfunctions when the ratio of the non-compressed volume V_U and the compressed volume V_P was greater than 3.5. A very high average hardness and in particular strongly increased individual values were found in bales of this type. Average hardness values, measured on the top side of the bale surface, were greater than 50 and individual values of greater than 60 were also present. The filter rods produced from these bales exhibited scattering values of the draw resistance that were above the desired, previously described values.

When producing bales according to the invention that have a packing density of greater than 450 kg/m^3, care has to be taken that the ratio of the non-compressed volume V_U and the compressed volume V_P is significantly lower than the previously stated value of 3.5. In order to obtain bale hardness values that are less than 50 on average, and in which case there should be no individual hardness values of greater than 55, a ratio of the V_U to V_P of less than 3.2 should be the goal. Within the context of the invention, particularly those filter tow bales were preferred that had an average Shore hardness on the surface of the bale of less than 45, with preferably no local hardness values of greater than 55. In general, this is achieved on account of the fact that the ratio of V_U to V_P is further decreased, in particular to a value of less than 3.1.

The ratio of the non-compressed volume to the compressed volume is dependent on a number of factors that mutually influence one another. The width of the band, i.e. the width of the filter tow band in the bale, as well as the so-called aggregation factor, are especially important among these factors.

It has been shown that the non-compressed volume V_U of the filter tow bale (and therefore the volume ratio of non-compressed compressed filter tow bale) can be reduced by means of a suitable arrangement of the filter tow within the bale. The reduction of the non-compressed volume, as already mentioned previously, can be achieved on account of a reduction of the average width of the filter tow in the bale. In accordance with the invention, maximal limits for the values of the average width were determined as a function of the total titer. Accordingly, the tow width in the bale has to be less than 50 mm when the tow exhibits a titer of more than 30,000 dtex, or maximally be 1.7×10^{-6} (m/dtex) x total titer (dtex), when the tow has a total titer of less than 30,000 dtex. Adherence to the stated value guarantees a non-problematic drawing of the filter tow from the bale during a subsequent processing method as well as low draw resistance fluctuations in the final product. Tow widths in the bales of less than 45 mm, when the total titer of the filter tow is greater than 30,000 dtex, or tow widths of less than 1.5×10^{-6} (m/dtex) x total titer (dtex), in case the total titer is less than 30,000 dtex, have shown to be particularly preferred within the context of the present invention.

The teachings according to the invention, according to which a low fluctuation of the draw resistance can be achieved on account of the fact that the width of the filter tow in the bale is kept below a certain limit is diametrically opposite to the opinion prevailing to date among those skilled in the art in the area of the production and processing of filter tow, according to which a narrow filter tow is frequently seen as a serious quality deficiency. This is so, because in the case of tow bales of low width, problems frequently occur during the pneumatic spreading while the filter tow is further processed into filter rods, which necessarily results in width fluctuation during the spreading process in the filter rod machine. The result of this, in turn, again are fluctuations in the draw resistance that are above the quality limits mentioned in the introduction. Within the context of the invention, however, it was found that these difficulties are mainly caused on account of the fact that a reduction of the absolute width of the filter tow band is

frequently accompanied by an increase of the relative width variation. It is this increased relative width variation that is primarily responsible for the width fluctuations during the spreading process taking place in the filter rod machine. It was possible to show that an overall reduction of the scattering of the draw resistance values of the finished filter tow tip can be achieved as a result of the reduction of the average width, when care is taken to insure that the width fluctuations of the tow in the bale is less than ± 12% of the average width of a filter tow. Filter tows whose fluctuation width is less than ± 10% are particularly preferred.

The mentioned, desired fluctuation widths are below those that are usually accepted for filter tow, as is shown by the following table. The tolerance values maximally permitted according to the prior art are shown in this table as a function of the average width and total titer of the filter tow.

Total Titer (dtex)	Average Width (mm)	Tolerance (mm)
15,000 – 20,000	28 – 48	max ± 6
20,000– 25,000	40 – 55	max ± 10
25,000 – 30,000	45 – 60	max ± 12
30,000 – 40,000	50 – 65	max ± 15
> 40,000	> 60	max ± 15

The tow widths listed in the table are common, since they have shown to be optimally suited for the packing of the bales as well as for the processing of the materials on some filter rod machines. For the specification currently used on a predominant basis, a width of approximately 52 mm is commonly cited (see Celanese Acetate, RodMap™ KDF2/AF2, Version 2.0, 1995). In this context, the width of the tow is a value that can easily be checked by the processor.

As is known to the one skilled in the art, the width of the filter tow, which is naturally dependent on the filament and total titer, can be influenced by a number of measures during the production process. Among the measures that should be mentioned, amongst others, are the width of the band guides, the moisture of the filter tow when being fed into the crimping machine, the roller width of the crimping machine, the geometry of the crush chamber and the type and manner in which the filter tow is mechanically stressed during and after drying up to the time it is placed in

the bale. Filter tow, which exhibits no width fluctuations greater than ± 12% despite a reduced width, can be produced, for example, on account of the fact that the band is post-moistened in the crush chamber or after the exiting from the crush chamber crimping and prior to being fed into the dryer with at least 20 g of water (or water vapor) per kg of filter tow.

Aside from decreasing the scattering of the draw resistance values, the fluff [or: slub – translator] formation that interferes with further processing, can also be reduced significantly with the help of this measure.

As a function of the total titer, a value of approximately 0.7×10^{-6} (m/dtex) x total titer (dtex) is viewed as the absolute lower limit of the width that is possible or makes sense from the processing perspective. It is possible, however, that the advantage achieved by the reduction of the non-compressed volume in terms of the scattering of the draw resistance value is already nullified below an average width of 0.8×10^{-6} (m/dtex) x total titer (dtex) on account of the processing problems that occur during the further processing of the filter tow so that starting from this value, no further increases in the quality can be achieved as the result of an additional reduction of the width.

Aside from the reduction of the width of the band, a favorable ratio of non-compressed and compressed volume can also be achieved on account of the already previously mentioned aggregation factor. The so-called aggregation factor H is an important value that describes the coiling of the band in the bale. It described the ratio consisting of the length of the completely uncrimped filter tow of a lay to the length of the lay.

$$H = L_0/L_A = 10{,}000 \times m_A\,(g) \,/\, \text{total titer}\,(g/m) \,/\, L_A\,(m),$$

Wherein m_A is the weight of a lay of filter tow in the bale, L_A is the length of a lay of filter tow in the bale (this corresponds to the length of the bale) and L_0 is the length of a completely uncrimped lay of filter tow. The higher the aggregation factor, the smaller the draw-off rate of the band directly from the bales and therefore interference during band-to-band separation. If the values are too high, however, complications are seen with the filter tow that is common

nowadays, which can finally result in band ruptures during processing in the filter rod machine. Also, the interference called "whip[ping] effect" that occurs at the reversal points due the reversal in the direction of the band is influenced to a considerable degree by the aggregation factor. In this case, low values result in an increased frequency of difficulties. A comprehensive test of products available in markets worldwide has that common value for the aggregation factor are between 11 and 22. Some values up to 30 are seen, but they are the exception.

Tests within the context of the present invention, however, have shown that in terms of the objective of achieving fluctuations of the draw resistance that are as low as possible, aggregation factors, whose values are clearly above those that are common to date, are preferred. It was found that optimal draw resistance values were achieved when the value of the aggregation factor is above approximately 20 and below approximately 35. Aggregation factors of greater than 25 and in particular of greater than 30 are particular preferred within the context of the invention. A non-problematic draw off of the filter tow from the bale is achieved within the stated ranges, in which case the occurrence of the "whip effect" can largely be avoided. A value of the aggregation factor of greater than 35, however, should be avoided due to the increased occurrence of complications of the band.

In particular, the aggregation factor should be chosen in such a manner that an effective layer width of the filter tow of 65 mm is not exceeded. Preferably, an effective layer width of less than 65 mm and in particular of less than 60 mm is desired in order to minimize the non-compressed volume. The value of the effective layer width depends on the width of the filter tow band as well as on the aggregation factor. Said value is calculated with the help of the following equation:

$$B_{eff} = B \times (1 + H / 100)$$

With B_{eff} denoting the effective layer width.

Another characteristic value of a filter tow bale is the so-called deposition [or: layering – translator] frequency F. This is defined as the number of longitudinal traverses [or: travels] of

the layer per transverse traverse. A complete layer of filter tow with F deposition paths therefore has the following total mass:

$$M = F \times m_A = F \times H \times \text{total titer (g/m)} \times L_A(\text{m}) / 10{,}000$$

With m_A denoting the mass of a deposition path and L_A being the length of a deposition path.

The deposition frequency F is set independent of the deposition pattern in such a manner that as uniform and planar a surface as possible is produced even in the non-compressed state. It was found that an optimal layer is achieved when the product consisting of the deposition frequency F and the effective layer width B_{eff} of a band is approximately the same as the width of the bale. This is shown with the help of the following relation:

$$F \times B_{eff} \cong \text{width of the filter tow bale}$$

With the help of empirical tests, it was found that the average height of a layer of non-compressed filter tow approximates the value of about 10 mm as soon as more than 500 kg are filled into a compression can and the previously mentioned relation is adhered to. This results in an optimal layering of the filter tow in the bale, which in turn results in the fact that the draw-off of the filter tow from the bale in the context of the further processing to filter rods is without problems, i.e. takes place without interferences so that the produced filter rods can achieve excellent values in regards to the scattering of the draw resistance values.

The invention is explained in greater detail below with the help of two embodiments.

Comparative Example:

A filter tow band with a filament titer of 3.3 dtex and a total titer of 38,500 dtex is spun. The filament cross-section has the shape of a "Y". The band is crimped in accordance with a conventional crush chamber method. After passing through the dryer, the band, with a moisture of 5%, is placed into a storage can with a basal surface of $L_0 \times B_B$ = 1,200 mm x 1,000 mm.

During deposition into the can, the filter tow has a width of 62 mm ± 9 mm. The packing machine for the loading of the material is set in such a manner that an aggregation factor of 20 and a deposition frequency F of 13 results. Following the loading of a total of 605 kg of filter tow, a non-compressed volume V_U of 4.2 m^3 is established. The filter tow is then compressed to a final volume of 1.2 m^3 and packed as usual.

After being stored for one week, the bale is opened; first to determine the surface hardness and secondly in order to produce filter rods for the determination of the draw resistance. In addition, the width of the filter tow is measured during unwinding.

The measurement of the Shore hardness, measured at the surface of the bale, results in an average value of 58 with a standard deviation of 10.55. The highest value was determined to be 71 and the lowest to be 43.

Filter rods with a length of 126 mm and a diameter of 7.8 mm are produced from this bale on a filter plug machine KDF2/AF2 with a processing rate of 400 m/min. The nominal draw resistance was 350 daPa. A coefficient of variation of 3.5% was determined from 10 random samples of 5 measured filter rods each, with the maximum value being 5.2%.

The width of the filter tow during unwinding was determined as follows: the filter tow is drawn off at a rate of 100 m/min onto a filter plug machine KDF2/AF2. During this process, the air [flow] from a first expansion nozzle is turned off. A line camera is placed 300 mm below the expansion nozzle for the measurement of the tow width. The evaluation of 100 individual measurements (one measurement every 3 seconds) yielded an average tow width of 66.3 mm, with the lowest individual value being 48 mm and the highest being 81 mm.

Example 1:

A filter tow band with a filament titer of 3.3 dtex and a total titer of 38,500 dtex is spun. The filament cross-section has the shape of a "Y". The band is crimped in accordance with a

conventional crush chamber method. Following the crimping process, the filter tow is post-moistened with 10 g of water per kg of tow.

After passing through the dryer, the band, with a moisture of 5.5%, is placed into a storage can with a basal surface of $L_0 \times B_B$ = 1,200 mm x 1,000 mm. During deposition into the can, the filter tow has a width of 45 mm ± 4 mm. The packing machine for the loading of the material is set in such a manner that an aggregation factor of 32 and a deposition frequency F of 17 results. Following the loading of a total of 605 kg of filter tow, a non-compressed volume V_U of 3.606 m^3 is established. The filter tow is then compressed to a final volume of 1.2 m^3 and packed as usual.

After being stored for one week, the bale is opened; first to determine the surface hardness and secondly in order to produce filter rods for the determination of the draw resistance. In addition, the width of the filter tow is measured during unwinding.

The measurement of the Shore hardness, measured at the surface of the bale, results in an average value of 43 with a standard deviation of 3.41. The highest value was determined to be 52 and the lowest to be 39.

Filter rods with a length of 126 mm and a diameter of 7.8 mm are produced from this bale on a filter plug machine KDF2/AF2 with a processing rate of 400 m/min. The nominal draw resistance was 350 daPa. A coefficient of variation of 2.5% was determined from 10 random samples of 5 measured filter rods each, with the maximum value being 3.4%.

The width of the filter tow during unwinding was determined as follows: the filter tow is drawn off at a rate of 100 m/min onto a filter plug machine KDF2/AF2. During this process, the air [flow] from a first expansion nozzle is turned off. A line camera is placed 300 mm below the expansion nozzle for the measurement of the tow width. The evaluation of 100 individual measurements (one measurement every 3 seconds) yielded an average tow width of 49.1 mm, with the lowest individual value being 40 mm and the highest being 51 mm.

Example 2:

A filter tow band with a filament titer of 3.3 dtex and a total titer of 38,500 dtex is spun. The filament cross-section has the shape of a "Y". The band is crimped in accordance with a conventional crush chamber method. Directly prior to the crimping process, the filter tow is moistened with 8 g of water per kg of tow and following the crimping process, the filter tow is post-moistened with 5 g of water per kg of tow.

After passing through the dryer, the band, with a moisture of 6.1%, is placed into a storage can with a basal surface of $L_0 \times B_B$ = 1,200 mm x 1,000 mm. During deposition into the can, the filter tow has a width of 35 mm ± 4 mm. The packing machine for the loading of the material is set in such a manner that an aggregation factor of 32 and a deposition frequency F of 19 results. Following the loading of a total of 605 kg of filter tow, a non-compressed volume V_U of 3.42 m^3 is established. The filter tow is then compressed to a final volume of 1.2 m^3 and packed as usual.

After being stored for one week, the bale is opened; first to determine the surface hardness and secondly in order to produce filter rods for the determination of the draw resistance. In addition, the width of the filter tow is measured during unwinding.

The measurement of the Shore hardness, measured at the surface of the bale, results in an average value of 41 with a standard deviation of 3.11. The highest value was determined to be 46 and the lowest to be 37.

Filter rods with a length of 126 mm and a diameter of 7.8 mm are produced from this bale on a filter plug machine KDF2/AF2 with a processing rate of 400 m/min. The nominal draw resistance was 350 daPa. A coefficient of variation of 2.0% was determined from 10 random samples of 5 measured filter rods each, with the maximum value being 2.7%.

The width of the filter tow during unwinding was determined as follows: the filter tow is drawn off at a rate of 100 m/min onto a filter plug machine KDF2/AF2. During this process, the air [flow] from a first expansion nozzle is turned off. A line camera is placed 300 mm below the

expansion nozzle for the measurement of the tow width. The evaluation of 100 individual measurements (one measurement every 3 seconds) yielded an average tow width of 40.1 mm, with the lowest individual value being 38 mm and the highest being 42.5 mm.

Figure 1 shows a schematic view of a bale surface with possible measurement points 1 to 9 drawn in. In this case, each of the measurement surfaces is about 100 mm x 100 mm. During the tests, the individual measured results at the various measurement points are entered into the table shown below and the average value as well as the maximum value are subsequently determined.

Measurement Point	1	2	3	4	5	6	7	8	9
Individual value									
Individual value									
Individual value									
Individual value									
Individual value									
Individual value									
Individual value									
Individual value									
Individual value									
Average value									
Maximum value									

* * *

CLAIMS

1. A filter tow bale with a packing density of greater than 450 kg/m^3, characterized by the fact
that the bale on its surface, measured vertically with respect to the lay of the tow, exhibits an average Shore hardness of less than 50,
that no local Shore hardness values of more than 60 are present, and the tow width in the bales is less than 50 mm, when the tow has a total titer of more than 30,000 dtex, or the tow width in the bale is maximally 1.7 x 10^{-6} (m/dtex) x total titer (dtex), when the tow has a total titer of less than 30,000 dtex,
that the value of the aggregation value is greater than 20 and
that the effective layer width is less than 65 mm.

2. The filter tow bale according to Claim 1, characterized by the fact that the bale on its surface, measured vertically with respect to the lay of the tow, exhibits an average Shore hardness of less than 45.

3. The filter tow bale according to Claim 1 or 2, characterized by the fact that the bale exhibits no local hardness values of greater than 55.

4. The filter tow bale according to at least one of the preceding claims, characterized by the fact that the tow width in the bale is less than 45 mm, when the total titer of the filter tow is greater than 30,000 dtex, and that the tow width is smaller than 1.5 x 10^{-6} (m/dtex) x total titer (dtex), in case the total titer is less than 30,000 dtex.

5. The filter tow bale according to at least one of the preceding claims, characterized by the fact that the value of the aggregation factor is between 23 and 35.

6. The filter tow bale according to Claim 5, characterized by the fact that the value of the aggregation factor is between 25 and 33.

7. The filter tow bale according to Claim 6, characterized by the fact that the effective layer width is less than 60 mm.

* * *

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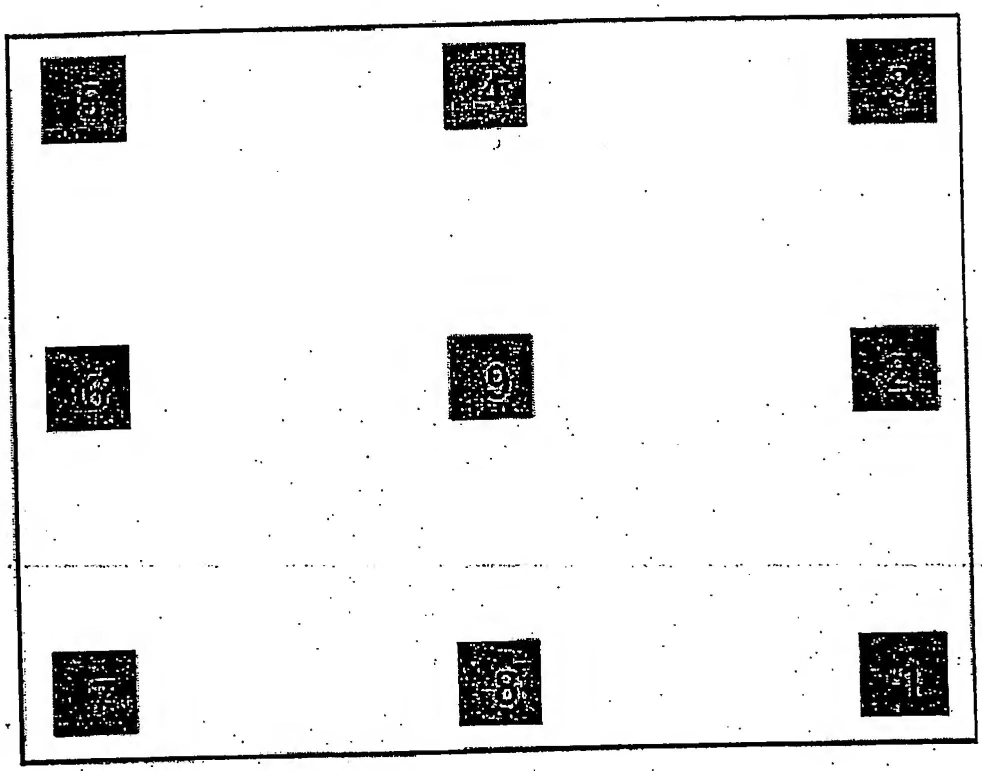

Fig. 1

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